Statistical model calculations for the decay of ^{48}Ti + ^{136,140,142}Ce systems.

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Introduction

At present, the interplay between the quasi-fission (QF) and fusion fission in the formation of compound nucleus (CN) is an important topic of research. For heavier systems, the probability of these processes is strongly influenced by the properties of the di-nuclear system at contact configuration where entrance channels plays a vital role [1]. On the other hand, various experimental observations have indicated the influence of shell closure and deformation effect on the formation of CN [2]. Thus, a detailed study of fission dynamic is important, which can be probed through ER, fission and fusion cross-section measurements.

Recently, Sharma et al. [3] measured evaporation residue (ER) cross-sections for ^{48}Ti + ^{142,150}Nd, ^{144}Sm systems leading to compound nucleus around Z_{CN} = 82, to investigate the deformation and proton shell closure effect. The targets ^{142}Nd & ^{144}Sm are spherical whereas ^{150}Nd is deformed in nature. The experimental ER cross-sections for one of the system ^{48}Ti + ^{150}Nd are higher than the other two systems, which is due to higher stability of CN ^{198}Pb (formed in the ^{48}Ti + ^{150}Nd) against fission as well as its higher shell correction energy as compared to CN formed in other two reactions. In addition, they compared the experimental ER cross-sections with the predictions from the statistical model of CN decay. It has observed from the comparison that ER cross-sections for ^{48}Ti + ^{142}Nd forming the CN ^{190}Pb is about an order of magnitude higher than ^{48}Ti + ^{144}Sm forming the CN ^{192}Po, due to shell closure of ^{190}Pb. Further, ER cross-sections for ^{48}Ti + ^{142,150}Nd systems are much smaller than the statistical model predictions. This indicates the presence of non-compound nucleus (NCN) processes in these two reactions.

Calculations

In this report, the theoretical calculations for ER, fission and fusion cross-section have been performed for ^{48}Ti + ^{136,140,142}Ce systems, to investigate the dependence of fusion reaction on deformation and shell structure of interacting nuclei. In the systems, ^{140}Ce target is neutron shell closed (N_T=82). Further, target ^{136}Ce is spherical and ^{140,142}Ce are deformed in nature. In Fig. 1, the cross-sections for ^{48}Ti + ^{136,140,142}Ce were compared. From results, no significant enhancement in values of cross-sections for system having closed neutron shell target (^{140}Ce) has been observed. This indicates that fusion process after surmounting the fission barrier may be same in the reactions ^{48}Ti + ^{136,142}Ce and ^{48}Ti + ^{140}Ce (N_T = 82).

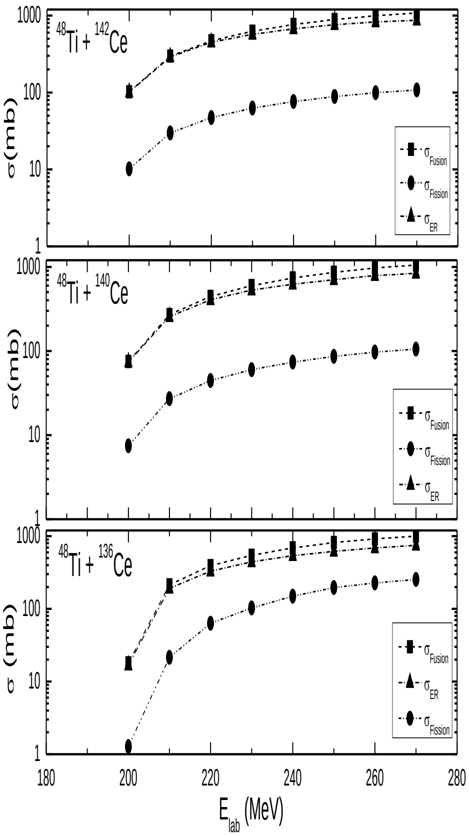

Fig. 1 Estimated ER, Fission and Fusion cross-sections using PACE code.

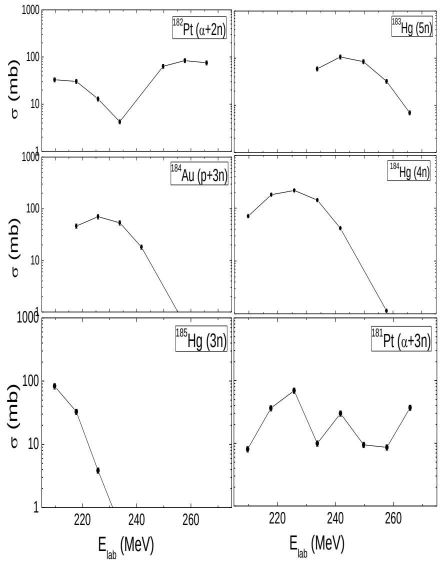

Fig. 2 Partial ER cross-sections for ^{48}Ti + ^{140}Ce system.

The calculated partial ER cross-sections for the ^{48}Ti + ^{140,142}Ce systems are plotted in Figs. 2 and 3 as a function of lab energy. The cross-section for ER for both the targets ^{140}Ce and ^{142}Ce widely differ from each other. As shown in Fig. 2, the maximum ER cross-sections for 5n and (α+2n) channels in the fusion reaction ^{48}Ti + ^{140}Ce are about 100mb for energies well above the coulomb barrier. On the other hand, the calculated ER cross-sections in the fusion reaction ^{48}Ti + ^{142}Ce decreases significantly for 5n and (α+2n) channels as shown in Fig. 3. We expect an additional energy (Extra push) for this system that makes the fusion barrier high and considerably decreases the ER cross-sections. The observed cross-sections corresponding to the maximum of 5n and (α+2n) channels is about two orders higher for system with closed shell target (^{140}Ce) compared with fusion reaction ^{48}Ti + ^{142}Ce. This result suggests that fusion process after surmounting the fusion barrier may be different in the reactions ^{48}Ti + ^{140}Ce and ^{48}Ti + ^{142}Ce. This contradicts the previous results. This deviation from general trend is not understood at present.

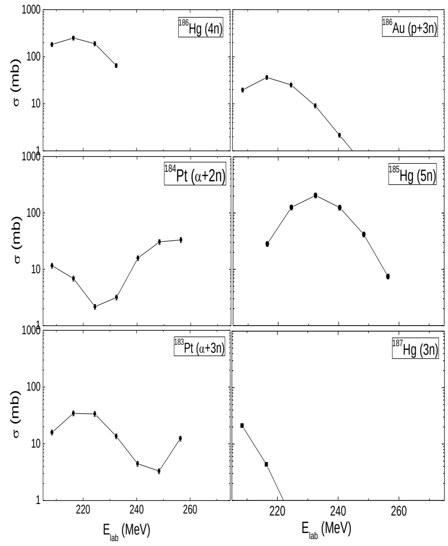

Fig. 3 Partial ER cross-sections for ^{48}Ti + ^{142}Ce system.

Conclusion

The present study indicates that it is very important to have experimental data and more theoretical analysis of these systems to identify the role of deformation and shell stabilizing effects of N = 82. Furthermore, it would be of considerable interest to populate the same CN with different entrance channel mass asymmetries to explore the possible role of entrance channel on fusion probability. Using HYRA spectrometer, we plan to do such experiments on ER cross-section measurements for ^{48}Ti + ^{136,140,142}Ce and ^{32}S + ^{156}Gd systems.

References

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